NON-WOVEN WARP YARN FABRIC MATERIALS AND METHOD AND APPARATUS FOR MANUFACTURING SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119 from commonly owned provisional application, U.S.S.N. 60/155,365, filed 20 September 1999, the disclosure of which is hereby incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to non-woven fabric materials and, more particularly, to a non-woven warp yarn fabric materials, which may be used as a substrate in the formation of other non-woven fabrics, particularly those that may have the appearance of a woven fabric, along with an apparatus and method for manufacturing the same.

SUMMARY OF THE INVENTION

In the present invention, a plurality of yarns are formed into an aligned group, substantially parallel and equally spaced apart, as described in greater detail below. This parallel grouping of yarns is advantageously fixed in place by forming an adhesive coating, printed on only one side of the yarns, using a hot melt roll coater. Cooling of the hot melt adhesive occurs almost

instantaneously, and the resulting product is a fixed web or substrate consisting essentially of a plurality of aligned yarns and an adhesive coating on one side of said fibers.

The preferred fabric-like material comprises substantially parallel yarn fibers (or fiber-substitutes) held together in a non-twisting manner by a series of adhesive bridges or a combination of adhesive and stray yarn fiber bridges on one side of the parallel fibers. This fabric-like material can be used as is, or it can be further transformed into other fabric-like materials by further processing.

As used herein, the term "bridges" is meant to define the physical result of applying a thin, discontinuous coating or layer of adhesive to one side of aligned warp yarns; namely a combination of adhesive strands, adhesive coated fragments of yarn strands, and/or fragments of yarn stands which contact adhesive on two or more aligned yarns (e.g., at two or more points), such that the series of aligned warp yarns are held together in a substantially user selected spatial arrangement, and wherein the yarns do not twist, rotate, or otherwise separate relative to one another due to the presence of the bridges on one side. In other words, the bridges lock the yarns in place in a manner selected by the manufacturer of the warp yarn material. Upon cooling of the adhesive, a flexible, yet unified substrate web of warp yarns having the look and feel of a nonwoven fabric, is obtained. This warp yarn substrate is suitable for further processing as a nonwoven fabric or otherwise. If desired, this combination of the warp yarns and adhesive may be wound onto a spool for later handling, or formed into sheets for other uses as desired.

The fiber orientation produced in this invention, in which the fibers run in the machine direction, provides a non-woven fabric material substrate in which the fibers mimic warp yarns, which can be used in subsequent non-woven manufacturing processes to make materials that have the visual impression and physical feel of a woven material. Such materials often exceed the physical characteristics of woven fabrics, particularly with respect to

strength, resistance to tearing, fraying, and the like, without the necessity of post treatments, including chemical treatments, to achieve these properties. Post treatments, if desired, could still be employed, particularly if beneficial properties were achieved thereby.

While the above-described adhesive method is preferred herein, other methods of preserving the aligned warp yarn strands could be employed. For example, the warp yarns can be contacted with a dry adhesive layer that is heated and then cooled to bond the materials; the adhesive could be applied with a melt blown applicator; or the aligned warp yarn strands could be bound via an adhesive to another layer of material, a coating of adhesive, or a substrate comprising adhesive and another non-woven fabric material.

Reference to the term yarn will be made throughout the description of the invention and the term should be broadly interpreted to include mono and multi-filament yarns and strands of material. The yarns may be large or small in diameter or denier, and can be made from many types of materials including but not limited to polyester, polyethylene, polypropylene and other polymers or plastics; wool, cotton, hemp and other natural fibers; blends of natural and/or synthetic fibers; glass, metal, graphite and the like. It is conceivable that some of the warp and/or weft yarns may be copper or aluminum wire. It should also be appreciated with the description that follows that various densities of warp or weft yarn wrap will be referenced and these densities will vary depending upon the type of yarn as described above and the desired characteristics of the non-woven product being manufactured.

The preferred apparatus of the present invention generates warp yarn fabric materials. For the purposes of this disclosure, warp yarn materials include any material or combination of yarns that has yarns or fibers primarily positioned to run in the machine direction of the apparatus and that are aligned in a controlled manner before being coated on one side with an adhesive material to form a fabric-like non-woven substrate.

One preferred embodiment of the warp yarn material generator of the present invention comprises a warp yarn aligner, through which a plurality of individual yarns or threads are passed to be placed in substantially parallel alignment. Once aligned, the yarns are next passed to the adhesive station, which is preferably a hot melt roll coater. In this device, a thin, discontinuous layer or coating of hot melt adhesive is imprinted on one side of the plurality of aligned warp yarns. The adhesive cools rapidly forming a web of weft yarns, suitable for further processing as a non-woven fabric or otherwise. If desired, this combination of the warp yarns and adhesive may be wound onto a spool for later handling.

The preferred warp yarn aligner has a plurality of vertically displaced sets of horizontally spaced rollers. The upper set of rollers is within a horizontal plane positioned above a horizontal plane containing the lower set of rollers, though it is conceivable that the orientation of the sets of rollers are not an upper and lower set of rollers but possibly a left and right set of rollers or somewhere in between so that the plane of the sets of rollers would be horizontally rather than vertically displaced or somewhere in between. The rollers are aligned transversely with each other. In the arrangement where the rollers are positioned within horizontal planes, each roller in a set is horizontally offset from rollers in the other set so that rollers in each set are positioned between rollers of the other set and the outer perimeter of the rollers in one set overlaps the outer perimeter of the rollers in the other set. In this manner the warp yarns which pass transversely through the sets of rollers must pass under the upper set of rollers and over the lower set of rollers contacting all of the rollers in each set with an engagement arc on each roller. It has been found that an engagement arc of about 20 degrees is preferable herein, although higher or lower degrees should also be useful. At least some of the rollers may be roughened on their outer surface to effect a light frictional engagement with the yarns.

The warp yarns that are roughly aligned when delivered to the rollers, e.g., through a comb device or otherwise, are passed through the spaces between the sets of rollers as described above. The rollers are driven at a roller-

face speed that is faster than the linear speed of the yarns. By over driving the rollers relative to the linear speed of the yarns it has been discovered that the yarns will become substantially parallel and evenly spaced. The textured rollers could be run at a speed slower than the yarns and achieve the same effect, but over speeding the rollers at a ratio within the range of 2:1 to 3:1 has been found to be very effective. Parallel alignment and even spacing of the warp yarns is important for most non-woven products because it results in a uniform appearance of the yarns which makes the end product look more like a woven product.

An especially preferred embodiment of the warp yarn material generator used herein comprises a warp yarn aligner, through which a plurality of individual yarns or threads (alike or different) are passed to be placed in substantially parallel alignment. Once aligned, the yarns are next passed to the adhesive station, which is preferably a hot melt roll (e.g., gravure) coater. In this device, a thin layer or coating of hot melt adhesive is imprinted on only one side of the plurality of aligned warp yarns. The adhesive is not a continuous film after application; instead, the adhesive typically partially separates when applied to the parallel yarns. Bridges of adhesive and/or fragments of yarn strands (each independently with or without an adhesive coating) form and/or otherwise extend over the spaces between parallel yarns. These bridges hold the yarns together and prevent individual yarns or threads from twisting relative to one another.

The preferred hot melt adhesive applicator is a Rototherm® hot melt roll coater. In operation of the hot melt adhesive coating apparatus the series of parallel warp yarns are drawn through the glue apparatus, supported by a series of rollers. A thin layer or coating (ranging from about 0.25 to 1 mil) of hot melt adhesive is continuously gravure coated. The actual thickness of the coating varies within the range specified, and depends upon the weight of the fabric, and is usually applied at from about 5% to 25% of the fabric weight. For a fabric weight of 50 g/m^2 the adhesive may be applied at from about 2 to 15 g/m^2, preferably at from about 5 to 10 g/m^2. After being gravure coated, the

warp yarn substrate rapidly solidifies, fixing the parallel arrangement and equal spacing of the yarns. A cooling path is provided to ensure that the adhesive is set before the substrate is rolled. Once rolled, the warp substrate product can be used in the manufacture of other non-woven products, or used as is, for example, as a light filtering screen for use in photography.

Other preferred details and advantages of the present invention will be apparent from the following detailed description, including the drawings accompanying this specification, which, by way of illustration, show preferred embodiments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagrammatic side elevational view of a warp yarn alignment unit and the hot melt adhesive applicator and cooling section, with parts removed for clarity;

Fig. 2 is a front-end elevation of the apparatus of Fig. 1;

Fig. 3 is a top plan view of the warp yarn material alignment unit shown in Fig. 1 with portions removed for clarity;

Fig. 4 is a top plan view of a portion of the warp yarn material alignment unit shown in Fig. 3, with portions removed for clarity;

Fig. 5 is a side elevational view of a preferred embodiment of the warp yarn material alignment unit;

Fig. 6 is a magnified photograph which shows the end product of this invention, a non-woven warp yarn fabric held together by bridges of dried adhesive, which span the gaps between the aligned yarns, locking them in place, preventing twisting;

Fig. 7 is an elevational view of the preferred Rototherm® hot melt adhesive roller coater (90) shown in the unengaged position, and showing the exit path of the adhesive coated warp yarn material (arrow);

Fig. 8 illustrates one preferred embodiment of the coating process, namely a direct imprinting process wherein the adhesive roller coated with a thin layer or coating of hot melt adhesive directly contacts the aligned yarn roller, which carries the aligned warp yarns to be imprinted with adhesive on one side only; and

Fig. 9 illustrates another preferred embodiment of the coating process, namely an indirect imprinting process, wherein the adhesive roller coated with a thin layer or coating of hot melt adhesive directly contacts a printing roller, which then contacts the aligned yarn roller, which carries the aligned warp yarns to be imprinted with adhesive on one side only.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figures 1-5 and 7-9 describe various embodiments of the warp yarn material manufacturing unit or portions thereof. The photograph of Figure 6 best shows the detailed relationship between the aligned warp yarns and the "bridges" of hot melt adhesive coating which holds the yarns together in a cohesive, non-twisting relationship.

As illustrated in Figures 1-5 and 7-9, the warp yarn manufacturing unit 82 includes a yarn supply station 94 which holds multiple horizontally and rotatably stored beams 96 of roughly aligned warp yarns which will ultimately be integrated into the warp yarn material.

It will be appreciated that the multiple beams of yarns are provided to achieve a desired warp yarn density, which is preferably about 40 to 90 yarns per inch. The yarn density range could be larger or smaller, depending upon the desired characteristics of the non-woven material, as well as the denier and

surface characteristics of the yarns used. Each beam of yarn is rotatably positioned and supported on a frame 98 in the manufacturing unit and restricted from freely rotating through use of a conventional brake or friction drag system 100 to allow proper feed of the yarns under tension into the alignment station. The yarns are pulled through the alignment station by the driven transfer roll 90.

The alignment station 86 includes two vertically displaced sets 102 and 104 of horizontally spaced rollers 106. The upper set 102 is within a horizontal plane positioned above a horizontal plane containing the lower set 104 of rollers, although it is conceivable that the orientation of the sets of rollers are not an upper and lower set but possibly a left and right set or somewhere in between so that the planes of the sets of rollers would be horizontally rather than vertically displaced or somewhere in between. The rollers 106 are transversely aligned with each other. Further, when the rollers are in horizontal planes the rollers in each set are horizontally offset from the rollers in the other set so that the rollers in each set are positioned between rollers of the other set and the outer perimeter of the rollers in one set vertically overlaps the outer perimeter of the rollers in the other set. In this manner, the warp yarns which pass transversely through the sets of rollers must pass under the upper set of rollers 102 and over the lower set of rollers 104 in a generally sinusoidal, or serpentine path as seen in Fig. 1. The warp yarns in the preferred embodiment arcuately engage approximately 20 degrees of each roller. The yarns could contact more or less of each of the rollers and the amount of contact could vary from roller to roller within a row of rollers. The preferred roller diameter is about 2 inches, though this diameter does not appear to be critical. In the illustrated embodiment there are 20 rollers in each set even though varying numbers of rollers might be used.

As can be appreciated in Fig. 4, the peripheral surface of the rollers 106 nearest to the yarn supply station 94 preferably have a coarser surface texture than the rollers closest to the adhesive application station 86. It will be appreciated that the surface roughness of the rollers, preferably, gradually decreases from the supply station to the adhesive application station. The

surface texture of the coarsest roller would preferably be finer than a 600 grit sandpaper and more particularly it is estimated that it would be similar to a 1000 grit sandpaper. The surface texture is very fine and is provided by the use of materials similar to those used in a conventional ceramic analox roll. The material used to provide the surface texture is a ceramic coating LC-4 provided by Praxair Surface Technologies of New Haven, CT. In at least one embodiment the rollers 106 positioned at the exit end of the alignment station 86 closest to the adhesive application station 88 are actually polished and, therefore, have a very smooth surface texture.

The rollers are rotatively driven by a drive system 108 to rotate about their longitudinal axes. The surface speed of the alignment rollers 106 is substantially greater than the linear speed of the warp yarns as they pass through the yarn aligner. The preferred ratio is from about 2:1 - 3:1 with the roller surface speed at about 200 to 300 feet per minute and the warp yarn linear speed at about 100 feet per minute. Because the roller surface speed is so much greater than the linear yarn speed, it is easy to understand why the warp yarn beams 96 must be restricted from freely rotating to prevent yarn overun. Other degrees of yarn/roller contact, roller speeds, roller to yarn ratios, surface textures, and surface texture gradients could be used. These parameters will be affected by at least yarn type, yarn size, and yarn material.

It is believed that over driving the yarns relieves tension and causes the yarns to relax and expand, while the texture on the surface of the rolls 106 causes the yarns to vibrate and shake causing them to hit their neighbor yarns thereby finding a home positioned approximately equidistant from each of their neighboring yarns. At present it is only conjecture as to why the yarns align in the yarn aligner, what is known is that the yarns do become substantially aligned as illustrated in Fig. 4.

As illustrated in Figures 1, 6, 8 and 9, a thin layer or coating of hot melt adhesive is applied to one side of the aligned yarns. The application may be direct as shown in Figs. 1, 5, 7, and 8, or it may be indirect as shown in Fig. 9.

This coating is air dried in a drying station and the resulting cohesive warp yarn fabric material (Fig. 6) is collected for further use.

At the adhesive application unit 88, the aligned warp yarns 84 are passed through a series of rollers into contact on one side with hot melt adhesive coater roller 90. This coater roller 90 is driven through a trough containing molten hot melt adhesive 116A and a thin (from about 0.25 to 1 mil thick) discontinuous layer of hot melt adhesive is gravure printed on one side of the aligned warp yarns 84.

Figures 1 and 7 illustrate the relationship between the adhesive roller 90, coated with a thin coating of hot melt adhesive 116A and the aligned yarn roller 122, which carries the aligned yarns 84. In Figure 7, the two rolls are shown in a disengaged mode. When these two rollers are put in contact with one another, the exposed side of the aligned yarns 84 is printed or coated with a thin layer of the hot melt adhesive 116A. As the melted hot melt adhesive 116A dries, it is transformed into a flexible but coherent layer 116B, as illustrated in Figure 6.

As shown in Figure 5, to ensure complete drying, the coherent web of aligned yarns and adhesive is passed through a drying station 95 in which it passes over a series of rollers to the take-up reel 125. At the take-up reel 125 the air-dried, non-woven warp yarn fabric material is collected for further processing.

The preferred adhesive is a hot melt adhesive that can be heated to activate and cooled to set, for example a hot melt copolyester polymer. One such adhesive is EMS Grillon 1533 copolyester, produced by EMS Chemie of Sumter, South Carolina. The warp yarn, by way of example, may be a 36/1 spun polyester yarn available from Burlington Industries of Greensboro, North Carolina, or from Carolina Mills of Maiden, North Carolina. Another warp yarn may be a 30/1 slub yarn (spun polyester) available from Uniblend Spinners Inc. of Conway, South Carolina.

The warp yarn fabric material of the present invention is especially suited for further processing in apparatus disclosed in PCT Publication No. WO 00/41523. This PCT publication, which designates the United States, is hereby incorporated herein by reference.

Although the present invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made by way of example, and changes in detail or structure may be made without departing from the spirit of the invention as defined in the appended claims.